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Technical Memorandum No. NMC-TM-64-13

EVALUATION OF THE COMPATIBILITY OF THE AQM-37A TARGET AND LAU-24/A LAUNCHER WITH THE F-4B LAUNCH AIRCRAFT

By

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31 March 1964

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Point Mugu, California

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This report describes work accomplished under WEPTASK RM-4501-001, Problem Assignment RM-45-1, AQM-37A (KD2B-1) Target System Support.

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SUMMARY

The AQM-37A target is a preprogramed, high-performance, air-launched, liquid-fueled, rocket-propelled, expendable missile target designed for launch from many types of military aircraft. The aerodynamic, structural, and electrical compatibilities of the AQM-37A target and the LAU-24/A launcher with the F-4B aircraft were evaluated. Prior to this evaluation the target had been launched only from F-3B and A-4B aircraft.

The evaluation, consisting of ground tests and flight tests, indicates that the centerline station of the F-4B aircraft is readily converted to a very satisfactory launch platform for the AQM-37A target. Launches within the subsonic flight regime at altitudes between 30,000 and 40,000 feet have been conducted without producing any effect detectable by the pilots or through observation of films upon the flight capabilities or characteristics of the aircraft.

INTRODUCTION

The AQM-37A (formerly KD2B-1) missile target is capable of simulating high-performance aircraft. This target has been developed for the U.S. Navy by the Beech Aircraft Corporation, Wichita, Kansas, as part of the AQM-37A expendable powered target system.

The compatibility of the AQM-37A target and the LAU-24/A launcher with the F-4B aircraft has been evaluated to determine whether the centerline station of the F-4B could be used as a launch point without danger of jeopardizing the mission or the safety of flight of either the target or the launch aircraft.

Authorization was granted by a BUWEPS letter (RM-451:IFJ), dated 21 December 1960, for Beech Aircraft Corporation to proceed with powered free flights of the AQM-37A target, as part of the flight-testing program. This letter also delegated to the Commander U.S. Naval Missile Center (COMNMC), the responsibility for establishing operational standards and safety and range requirements, with particular attention to be given to details which might cause malfunction during launch and flight.

This evaluation was performed under WEPTASK RM-4501-001/225-1/S417-B0-03 and Problem Assignment RM-45-1.

This report is limited to a description and evaluation of preliminary checks of mechanical fit, electrical continuity, and adequacy of power supply; 1 straw-pit launch, on 22 July 1963; 2 captive-target flight tests, on 23 July 1963; and 3 live-target launches, during July and August 1963, at altitudes of 40,000 to 43,000 feet and at Mach 0.90 to 0.92. It does not include any data obtained from strain-gage tests, or through telemetry or flight instrumentation, nor any investigation of supersonic launches.*

Following a description of the target, launcher, and aircraft under consideration and a listing of the test equipment used, the trial installation of the components of the AQM-37A target system on the aircraft is described. Exploratory ground tests, consisting of engineering studies of clearances, strength, and electrical and aerodynamic stability are enumerated. The flight-test phases, as well as routine target-practice operations with missile-firing aircraft on the Pacific Missile Range are then described and evaluated. For the purposes of this report, the "target system" is defined as the AQM-37A target, the LAU-24/A launcher, the pylon adapter, the electrical adapter cable, the F-4B T-system wiring and power supply, and the AQM-37A release console in the pilot's right-hand cockpit console.

*It has been learned that prior to this report date, the Fleet had successfully launched one AQM-37A target from an F-4B aircraft at 1.3 IMN at an altitude of 40,000 feet. The aircraft had been catapult-launched from an aircraft carrier.

DESCRIPTION OF COMPONENTS

AQM-37A Target

The AQM-37A target is an air-launched, liquid-fueled, rocket-propelled missile target designed to fly at a speed of Mach 2 at an altitude of 70,000 feet, and capable of simulating high-performance aircraft. It is a center-delta-wing monoplane with fixed vertical stabilizers mounted on each wing tip. Pitch control is provided by forward canard surfaces, while guidance and control is achieved by a free gyro for roll and azimuth reference, and by an altitude sensor for altitude and rate-of-altitude-change data. Two electrical servos, mechanically linked to the canard and aileron surfaces, receive electrical impulses from the guidance system, which is preprogramed for control of the target. The target, powered by booster and sustainer rockets, is capable of supersonic cruise at altitudes from 1,000 to 70,000 feet. The flight-ready target weighs 560 pounds gross. The fuselage is 162.7 inches long and 13 inches in diameter. The delta-wing span is 39.5 inches; the vertical stabilizer is 20.0 inches in height.

LAU-24/A Target Launcher

The LAU-24/A target launcher weighs 181 pounds and is a cartridge-actuated, forced-ejection, scissors-linkage type. Its mounting bolts were designed to correspond, in location and size, with those of the Aero 7A or Aero 27A ejector rack assembly so that it can replace either of these racks without the use of an adapter, if this type of installation proves advantageous.

F-4B Aircraft

The F-4B aircraft is a low-wing, twin-jet-engine fighter aircraft which is in widespread use by the U.S. Navy and is capable of carrying a number of externally-mounted bombs or other stores.

TEST EQUIPMENT

Table 1 indicates, by an X in the appropriate column, the equipment used for the different tests.

PROCEDURES

Ground Tests

Prior to modifying the F-4B aircraft by the addition of an external store which would place a drain on the aircraft's electrical system, preliminary studies were conducted to eliminate all the known possibilities of endangering the safety of flight of the aircraft.

Table 1. Equipment Used for the Different Tests

Test Equipment	Ground Tests		Flight Tests	
	Preliminary	Straw-Pit Launch	Captive Target	Target Launch
F-4B aircraft with T-system wiring and power supply	X	X	X	X
AQM-37A release console installed in F-4B cockpit	X	X	X	X
Pylon adapter		X	X	X
LAU-24 A launcher	X	X	X	X
Electrical adapter cable	X	X	X	X
Bomb trailer--Mk 7, Mod 1 or Aero 16B-Aero 48A with AQM-37A combination cradle assembly	X	X	X	X
Voltohmmeter	X			
Dummy AQM-37A target		X		
Cameras, tripods		X		
Live AQM-37A targets			X	X
Airborne camera equipment			X	X
Yarn segments for airflow studies			X	
Chase aircraft			X	X

Preliminary Steps and Initial Tests

Before the F-4B aircraft was available for the compatibility evaluation, a study was made of the F-4B wiring diagrams (shown in NAVWEPS 01-245-FDB2-10.1).

The study disclosed that the F-4B aircraft contained a centerline-station, missile-release wiring circuit (known at the T system) which was readily adaptable to a compatible AQM-37A launch system. Beech Aircraft Corporation, utilizing the LAU-24 A launcher of the AQM-37A, F-3B system, proceeded to develop a relay box for the electrical function of the LAU-24 A launcher which could be used with F-3B, F-4B, and A-4B aircraft. Beech also developed the AQM-37A release console for use in the F-4B aircraft for the centerline station. After installation of the AQM-37A electrical adapter cable, checks of wiring continuity and DC power output were made to test the compatibility of the F-4B T-system wiring, the LAU-24 A launcher, the AQM-37A release console, the newly developed "universal" relay box, and the AQM-37A target.

Figure 1 is an electrical schematic diagram showing the release console, the T-system wiring, the F-4B armament bus wiring, the electrical adapter cable, and the "universal" relay box in the LAU-24/A launcher used to provide warmup, launch, and jettison power for the AQM-37A missile target. Figure 2 shows the AQM-37A release console installed in the pilot's right-hand cockpit console of the F-4B aircraft, where the T-249 control panel had originally been installed.

Beech developed a cast aluminum alloy pylon adapter assembly to fit the LAU-24/A launcher to the F-4B aircraft, using steel hanger lugs to snap into the attachment points of the standard Aero 27A ejector rack assembly at the centerline station. Figure 3 is a close-up view showing the pylon adapter, the LAU-24/A launcher, and a live AQM-37A target beneath an F-4B aircraft.

The following steps must be performed to convert a Fleet-configured F-4B aircraft to an AQM-37A launch aircraft:

1. Install the pylon adapter assembly (Beech part No. 1019-392063) on the LAU-24/A launcher, using the four attach bolts furnished and ensuring that the adapter cable has been secured to the electrical connector in the LAU-24/A launcher.

2. Attach the AQM-37A electrical adapter cable to the mating connector in the F-4B fuselage and snap the assembly to the Aero 27A ejector rack assembly at the centerline station.

3. Remove the T-249 control panel from the pilot's right-hand cockpit console.

4. Install the AQM-37A release console in the spot left vacant by the removal of the T-249 control panel.

5. Install an AQM-37A target on the LAU-24/A launcher.

Three F-4B aircraft (Bu.Nos. 150455, 150481, and 150639) were converted in this manner to launch AQM-37A targets; each aircraft was easily converted within 1 hour by three men.

Figure 4 is a rear view of the nearly completed installation showing the clearances present when the Mk 7 trailer is used for loading.

Figure 5 is a front view of the completed installation.

Straw-Pit Launch Test

A dummy AQM-37A target was launched into the PMR straw pit from an LAU-24 A launcher secured to the centerline station of an F-4B aircraft

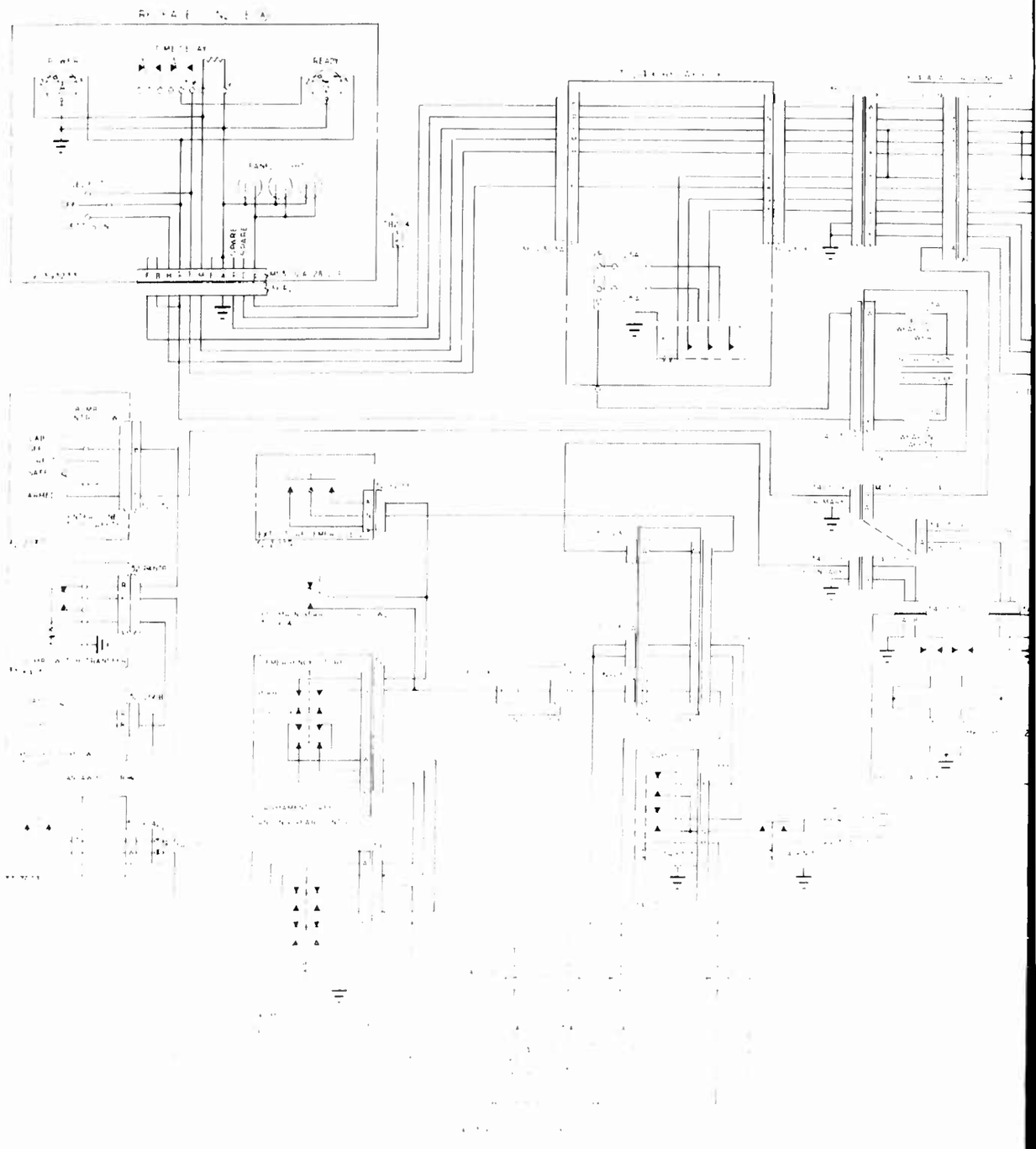
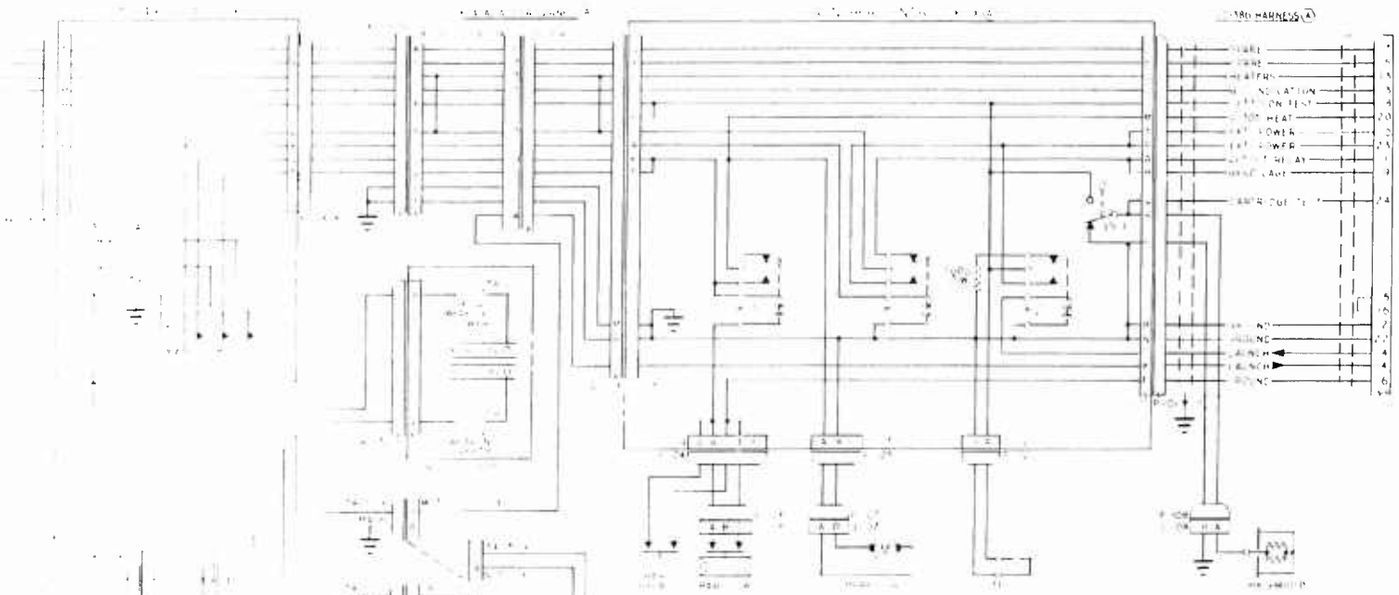


Figure 1. F-4B-AQM-17A Electrical Wiring Schematics



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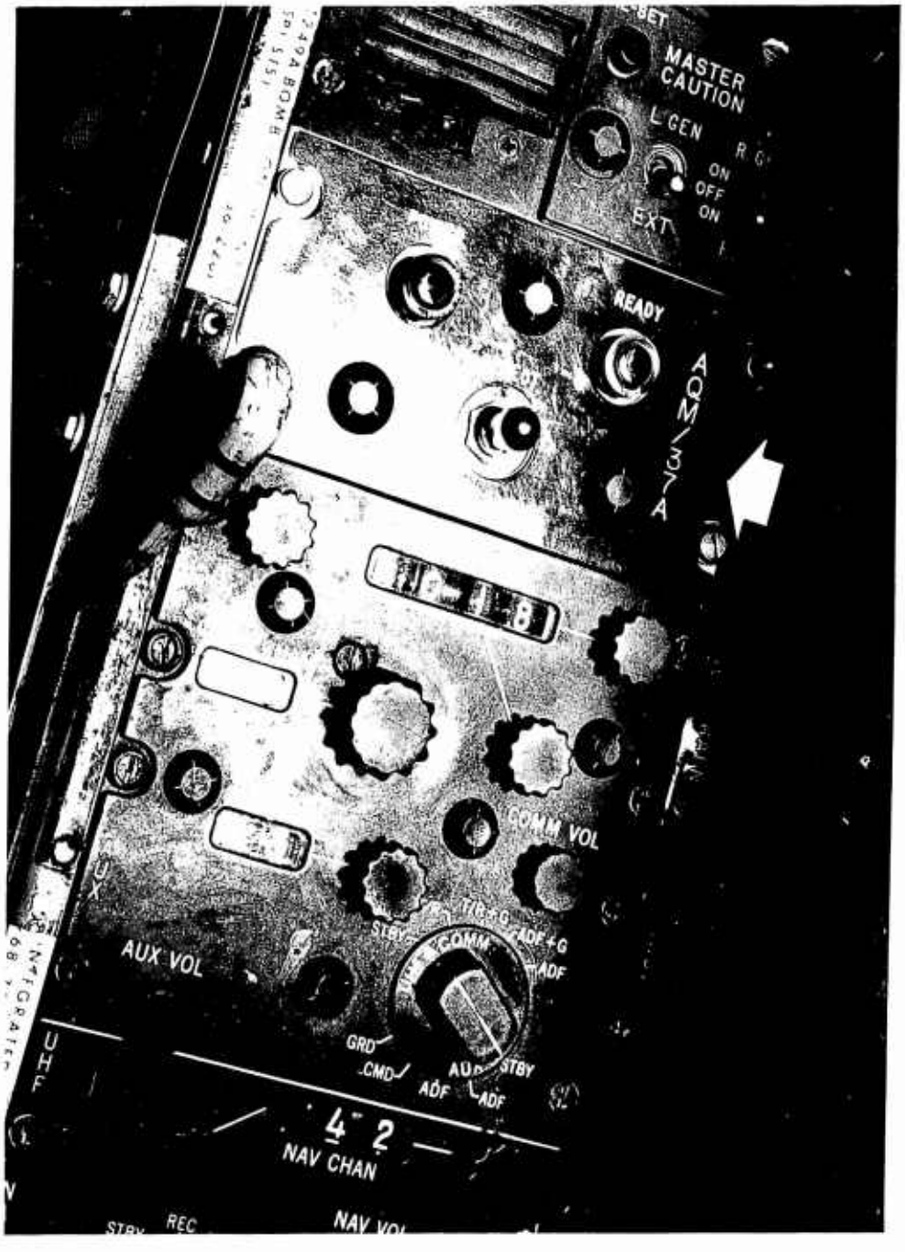

Figure 2. AQM-37A Release Console Installed in Right-Hand Cockpit Console of F-4B Aircraft.

(Bu.No. 150455). The purposes of this launch were (1) to test the electrical circuitry of the aircraft compared to the wiring diagrams, (2) to study the angle of departure of the target from the aircraft, and (3) to note whether the 8g force imparted to the target upon separation would have any visually detectable reaction on the aircraft. The dummy AQM-37A target had the same center-of-gravity location as a live target. This launch was photographed in color by a

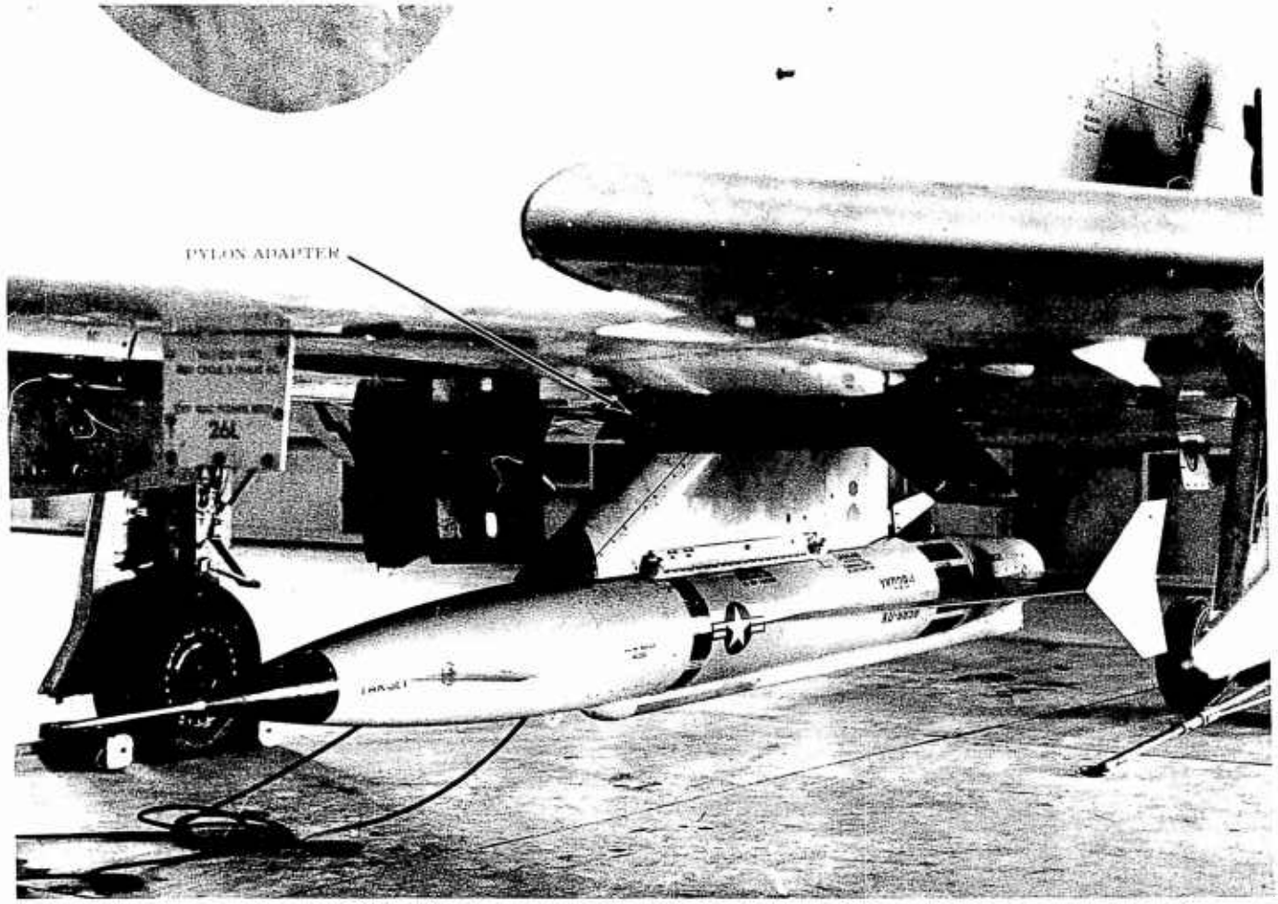

Figure 3. Pylon Adapter, LAU-24/A Launcher, and Live AQM-37A Target on F-4B Aircraft.

Figure 4. AQM-37A Target Being Installed on F-4B Aircraft, Showing Clearances When Mk 7 Trailer Is Used for Loading.

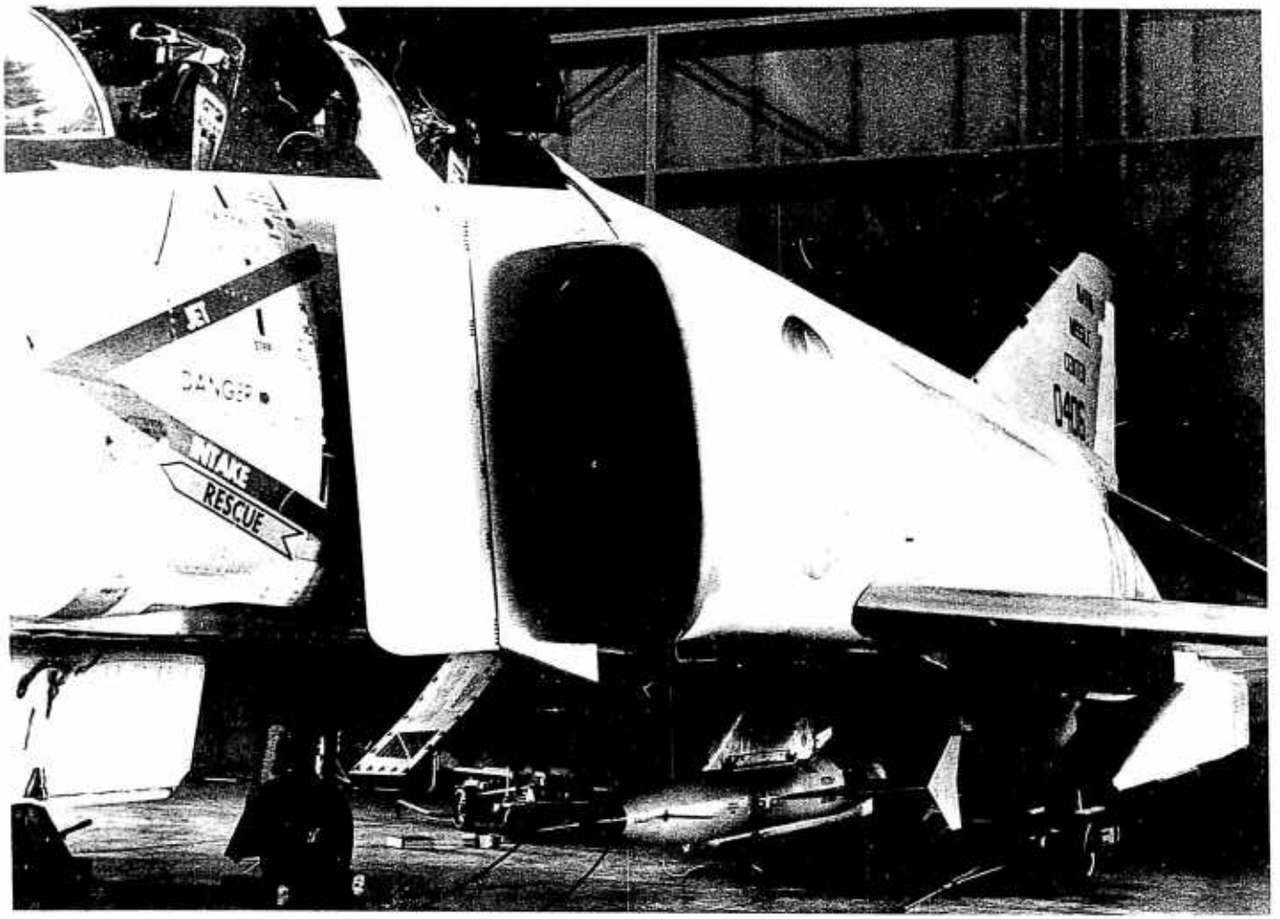

Figure 5. AQM-37A Target Installed on F-4B Aircraft.

high-speed motion picture camera so that the target-launch angle, as seen in the film frames, could be checked by protractor against previous aerodynamic studies.

Flight Tests

After completion of all preliminary studies and ground tests, the target/launcher/aircraft combination was considered ready for the flight-test phase of the compatibility evaluation.

Captive-Target Flight Tests

Two captive-target flights were made on 23 July 1963, with an F-4B aircraft (Bu.No. 150455) carrying an AQM-37A target and an LAU-24/A launcher secured to the centerline station. The purposes of these captive-target flights were (1) to check the effect of the presence of the target on the taxi, takeoff, climb, cruise, and landing characteristics of the aircraft, (2) to check, through a wide variety of maneuvers, whether the installation was free from objectionable vibration and had sufficient mechanical strength, and (3) to check for the presence of any upward airflow around the canard area of the target.

The airflow around the target nose was recorded by a wing-pod camera photographing rows of yarn tufts which had been attached to the flank of the target confronting the camera, in various planes through the target axis, so that upward or downward flow of air in the area of the target canards would be indicated from the position taken by the free ends of these tufts. Excessive fluttering of these yarn tufts would indicate air turbulence which would cause undesirable target vibration.

The judgment of the pilot was the only evidence deemed necessary to indicate any change in the flying and handling characteristics of the aircraft.

Extreme maneuvers were performed most frequently during descent and prior to high-Q runs. A -1g pushover, a +4g pullup, maximum sideslip, rapid rates of roll, and banks were performed.

In order to check the operation of position and acceleration sensors, and related servomechanisms of the target, an antenna was installed at the lower surface of the target to transmit, on a monitored telemetry channel, the following information:

1. Responses from longitudinal and vertical accelerometers in the target.
2. Signals from gravity-directed gyro in the target.
3. Reactions of pitch and yaw axis gyros of the target.
4. Dynamic pressure at the tip of the target's nose cone as sensed by an aerohead pitot transducer.

Target-Launch Flight Tests

Three different pilots successfully launched a total of three AQM-37A targets from F-4B aircraft (Bu.Nos. 150455, 150481, and 150639).* The maximum altitude of launch was 43,000 feet and the maximum speed was 0.92 IMN (indicated Mach number). The primary mission of these flights was the regularly scheduled launch of AQM-37A targets as part of the contractor's research and development program; however, a secondary mission was the testing of the compatibility of the F-4B aircraft, the LAU-24/A launcher, and the AQM-37A target. These three launches were photographed by motion picture cameras from a chase aircraft.

RESULTS AND DISCUSSION

The following evaluation is based upon the previously described studies of wiring diagrams, photographs, and films, as well as upon verbal reports and conferences.

Ground Tests

Preliminary Steps and Initial Tests

The ground continuity checks indicated that the combination of the F-4B/AQM-37A release console, the F-4B T-system wiring and power supply, the LAU-24/A launcher with the newly developed "universal" relay box, and the Beech-designed F-4B electrical adapter cable were in every way electrically compatible and would furnish the AQM-37A target with all the power necessary for warmup, prelaunch, and launch-command operations.

Straw-Pit Launch Tests

Visual observations and study of the film made of the straw-pit launch confirmed the proper operation of that portion of the electrical system concerned with launching, and proved that the same setting of the scissors arms of the LAU-24/A launcher used for the F-3B aircraft resulted in the proper amount of target nose-down attitude for apparent satisfactory separation.

It was concluded from these tests that this aircraft/launcher/target combination was ready for captive-target flight tests.

Flight Tests

Captive-Target Flight Tests

The test pilot for the captive-target flight tests could detect no difference in the taxi, climb, cruise, maneuverability, or landing characteristics of the F-4B aircraft resulting from the presence of the attached launcher and target.

*As of 31 December 1963, 22 AQM-37A targets had been successfully launched from F-4B aircraft.

Study of the films made during the captive-target flight tests showed that the airflow around the target ahead of its center of gravity always had a slightly downward or almost zero vertical component, and that the yarn tufts did not flutter except directly after takeoff of the aircraft, before the airflow pattern had stabilized.

Accordingly, it was indicated that no aerodynamic net reaction existed which would tend to force the nose of the target upward at the moment of launch, and that the ambient air was free from turbulence which might cause launch irregularities.

The angles assumed by the tufts indicated that the nose cone of the target received a slight downward force and that, particularly at that portion of the target directly ahead of the launcher juncture, a pronounced downward component of flow existed, as might be expected due to splitting of the air at the leading edge of the launcher.

Successful completion of extreme aerial maneuvers demonstrated that the installation had adequate mechanical strength and was free from vibration. Study of the telemetry records of position and acceleration sensors and related servomechanisms of the target showed normal action of these components during the captive-target flights, and thus indicated proper operating conditions for the target.

The F-4B aircraft accelerates rapidly when the afterburner is in operation with the nose momentarily down, which accounts for the fact that the target has been flown captive to a speed of at least 0.99 IMN, which is definitely in the transonic range. Under this condition the aircraft behaved in the same manner as without external stores.

Since the results of both captive-target flight tests were satisfactory, it was decided that the aircraft/launcher/target combination could be cleared for target-launch flight tests.

Target-Launch Flight Tests

The film data of the target-launch flight tests indicate that the vertical separation of the target from the aircraft under the accelerative force of the launcher is very rapid and smooth and that the target never loses its essentially horizontal attitude. This stability in horizontal attitude is due to the relative airflow acting upon the target's horizontal stabilizer, which is a highly swept-back delta wing. Vertical momentum of the target drives it far below the launch aircraft. During the period when the aircraft can be used as a visual reference in the films, the target does not appear to have moved behind the launch aircraft; in fact, the target initially tends to fly forward slightly faster than the launch vehicle as a result of the horizontal component of thrust imparted by the launcher.

The canard surfaces of the target are initially locked at an angle of -0.5 degree and are not released for gyro pitch control until about 2 seconds after launch, by which time the target is about 100 feet below the launch aircraft. Rocket ignition occurs 2.5 seconds following launch, and it requires at least 1 additional second to develop full thrust (3.5 seconds after launch). Before its rockets begin to accelerate the target rapidly away, the target is about 250 feet below the launch aircraft.

During one operation, a test was made to determine maximum launch altitude with respect to highest subsonic (nontransonic) speed for ease of pilot handling. With the afterburner on, the F-4B aircraft was brought to a speed of 0.95 IMN at an altitude of 45,000 feet for simulated launch. The afterburner was then turned off and the velocity decayed to 0.92 IMN. Under the condition of comparatively low ambient air density with respect to the speed of flight, the aircraft would not maintain an acceptable launch attitude. This condition, unrelated to the target, is inherent in the aircraft characteristics. For this reason, launches could not be made from the F-4B aircraft at altitudes over 43,000 feet at subsonic speeds.

The static instruments of any aircraft experience oscillations at a flight speed of about 0.95 IMN, since the aircraft has started to enter the transonic range. Therefore, launches were not attempted at speeds over 0.92 IMN because verification of launch aircraft attitude could not be assured. Aircraft launch speeds either under 0.92 IMN or considerably over the speed of sound and, hence, beyond the transonic range, would facilitate the reading of aircraft instruments.

Films of the target launchings indicate that the nose-down attitude of the target was satisfactory for separation and that no difficulty was experienced by the gyro control in establishing the target in the desired attitude of flight.

The cartridge in the launcher breech serves the purpose of launching or jettisoning the target. The jettison differs from the launch only in that the target is not activated for propulsion and guidance.

All factors (weight, drag, aerodynamic effects) imposed by the target-and-launcher installation were less severe than those imposed by a 600-gallon fuel tank which is already qualified for the F-4B aircraft at the centerline station.

Three Navy pilots were involved in the test flights of the aircraft/launcher/target combination under consideration.

The flight handling characteristics of the F-4B aircraft with the AQM-37A target installed were considered entirely satisfactory by these Fleet squadron pilots. They regard the performance of the aircraft to be essentially similar to that without external stores. This performance is expected since the weight of the target system is only about 2 per cent of the combat weight of the aircraft, and since the equivalent flat-plate area of the target is about 1/2 square foot.

When the target was launched, the pilot felt what he described as a slight "thump" in the aircraft. However, this effected no change whatsoever in the stability of the F-4B aircraft.

CONCLUSIONS

It is concluded that:

1. After the removal of the T-249 control panel and the installation of the Beech-developed release console, the pylon adapter, and the LAU-24/A launcher with the "universal" relay box and adapter harness, the Fleet-configured F-4B aircraft, with T-system wiring and power supply, is acceptable as a launch aircraft for the AQM-37A target within the subsonic flight regime at altitudes between 30,000 and 40,000 feet.

2. Based upon the evidence from the tests just discussed, no factor exists which could in any way result in a threat to the safety of flight of either the AQM-37A target or the F-4B launch aircraft.

3. An F-4B aircraft can be converted to launch AQM-37A targets in 1 hour and can be reconverted to its normal flight configuration in an equal amount of time.

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